Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

**CANMET**

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

# MERCURY DOCUMENTATION - A COMPUTER PROGRAM TO REDUCE MERCURY POROSIMETRY DATA

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# 1. INTRODUCTION

Mercury intrusion has become a useful method of measuring sample porosities and pore size distributions in the field of rock mechanics.

Current research at the Mining Research Laboratories of CANMET involves rock property studies of crystalline igneous rock formations of the Canadian Shield. Pore characteristics are of particular interest; however, the porosities being measured tend to be very low.

Three corrections must be applied to the measurements in order to obtain valid results. Thus manual data reduction and graphical representation of the numbers become time-consuming and tedious processes. A computer program to execute the calculations and produce clear, comprehensive output would prove valuable.

Program MERCURY is an efficient program designed to handle several data sets from the Mercury Porosimeter at one time, and to create either PRINTERPLOT or CALCOMP plots of the results.

This report describes MERCURY, and the basic theory behind it, and documents recent changes which were made to generalize the program. The program can be adapted to handle any data from the Mercury Intrusion Porosimeter. The final section of the report illustrates data input for a typical example and shows the available output. A file listing of MERCURY is given in Appendix A, and Appendix B outlines the theory and test procedure for the Mercury Porosimeter.

# 2. MERCURY: THE FORTRAN PROGRAM

## 2.1. GENERAL OUTLINE

The program reads in all parameters from the porosimeter run, including the sample data. Pressure, count and hysteresis readings are stored in arrays dimensioned to forty, the expected maximum number of readings for a run. Prior to any calculations, the input data is printed out (Table 1A), so that it can be easily checked. Options for the output are read and print statements generated to indicate expected output (Table 1A).

Necessary unit changes are made, and the mercury head pressure is added to all pressure readings less than or equal to 0.69 MPa (100 psi). At each pressure increment, an external function is called to calculate the

Table 1A. - Output of the test example input data information

```
*****  INPUT DATA INFORMATION  *****

SAMPLE IDENTIFICATION              = WN1 390.60
WEIGHT OF SAMPLE (G)               =    37.2000
DIAMETER OF SAMPLE (CM)            =     2.4700
HEIGHT OF SAMPLE (CM)              =     2.9820
SAMPLE WT. +CELL+GREASE SEAL (G)   =    81.9700
SAMPLE WT. + HG + CLAMP (G)        =   264.8500
DISPLACEMENT COUNT                 =    72.0000
WEIGHT OF CLAMP (G)                =    39.6200
SAMPLE WT. AFTER TEST (G)          =    37.4600
NUMBER OF READINGS                 =         22
VOL. OF HG POROSIMETER CELL (CC)   =    24.7100
CELL FACTOR (CC/COUNT)             =      .0004
BLANK RUN SLOPE (COUNT/PSI)        =      .0043
INTERCEPT OF BLANK RUN (COUNTS)    =    -5.4175
POISSON'S RATIO                    =      .2600
YOUNG'S MODULUS (MPA)              =   .7100000E+05

A PRESSURE VS. INTRUSION GRAPH IS PLOTTED

A PORE VOLUME VS. PORE DIAMETER GRAPH IS PLOTTED AND  7 INITIAL DATA POINTS ARE ERASED FROM THE PLOT

A PORE SIZE DISTRIBUTION GRAPH IS PLOTTED AND  7 INITIAL DATA POINTS ARE ERASED FROM THE PLOT
```

total correction for the counts due to sample, cell and mercury compression. For rising pressure, the effect is cumulative, so that the correction can be directly subtracted. During hysteresis it is assumed that the mercury, sample, and cell will expand to their previous volume, at the same pressure. To account for this reverse effect, the corrections at each pressure are stored in an array, and the difference between the correction at maximum and current pressure is used to correct hysteresis count. This is a recent change to MERCURY, which was made so that linearity of the correction function need not be assumed. At pressures exceeding 103 MPa (15,000 psi) the function ceases to be linear; in some cases it is desirable to apply these higher pressures during a porosimeter run. (When testing diabase, for example.)

The corrected counts are multiplied by the cell factor, on input value, to give the intrusion volume at each pressure. Percent porosity is also calculated; a check variable in the program picks out maximum porosity (Table 1B).

The pore diameters corresponding to each pressure are calculated using the Washburn equation;

$$d = \frac{-4\sigma \cos\theta}{p} \qquad \text{Eq 1}$$

where $d$ = pore diameter

$p$ = pressure

$\sigma$ = surface tension of mercury

$\theta$ = contact angle.

The contact angle and surface tension of mercury are assumed to be 130° and 474 dynes/cm$^2$ respectively, so that the equation simplifies to

$$d = \frac{1.219}{p} \qquad \text{Eq 2}$$

where diameter is measure in microns, and pressure in megapascals.

Density of the rock sample is calculated two ways, using sample demensions, and using mercury displacement. Selected density is calculated using maximum porosity.

Table 1B. - Output of calculated rock densities and maximum porosity of the test example

| | | |
|---|---|---|
| BULK DENSITY BY MEASUREMENT IS | = | 2.6035 (G/CC) |
| DENSITY BY HG DISPLACEMENT IS | = | 2.6388 (G/CC) |
| SKELETAL DENSITY IS | = | 2.6442 (G/CC) |
| POROSITY OF THE SAMPLE IS | = | .2043 ( % ) |

The program allows for four optional outputs; a table, a plot of pressure vs intrusion, a plot of pore volume vs pore diameter, and a pore size distribution plot. These are controlled by IOPT 1, 2, 3 and 4 respectively. If the option is desired it is assigned a value of one; otherwise it is assigned a value of zero.

Table 1C shows pressure readings with corresponding counts, corrected counts, hysteresis counts, corrected hysteresis counts, intrusion volumes, pore diameters, hysteresis volumes and porosities. The first plot, pressure vs. intrusion, will be done with a logarithmic pressure axis if the plotting device used is CALCOMP (Fig. 1A) and a normal pressure axis if the plotting device used is PRINTERPLOT (Fig. 2A) (MERCURY is designed to create either CALCOMP or PRINTERPLOT graphs, depending on the control cards.) To obtain a better linear range of values for the second (Fig. 1B & 2B) and third plots (Fig. 1C & 2C), a number of initial readings at low pressures and thus very large diameters, are erased. The number of points deleted is controlled by an input parameter; by default at least one is erased. (The above given Fig. 1B, 1C, 2B and 2C seven initial low pressure readings are erased).

The third plot, the pore size distribution, is generated by calculating the slope of the intrusion volume vs pore diameter plot at each point. Thus the differential volume at the $n^{th}$ pore diameter is found by;

$$\frac{dv}{dD_n} = \text{slope}_n = \frac{V_{n+1} - V_{n-1}}{D_{n-1} + D_{n+1}} \qquad \text{Eq 3}$$

where V = instrusion volume
D = diameter.

Recent changes to MERCURY have generalized the program so that it can handle more than one set of data per run. As well, it has been made possible to generate more than one CALCOMP plot per run. Any number of data sets can be analyzed, with any particular graphs generated for each set, either CALCOMP or PRINTERPLOT, depending on the plotting device used during the run. The default value for the number of data sets analyzed is one, should a blank data card be encountered.

Table 1C. Output of input data: pressure readings with corresponding counts and calculated values of corrected counts, hysteresis counts, corrected hysteresis counts, intrusion volumes, pore diameters, hysteresis volumes and porosities of the test example

SAMPLE IDENTIFICATION WN1 390.60

| NO. | PRESSURE (MPA) | COUNT | CORRECTED COUNT | HYSTERESIS COUNT | CORRECTED HYS COUNT | INTRUSION (CC/G) | PORE DIA. (MICRONS) | HYS VOL. (CC/G) | POROSITY (PERCENT) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | .028 | 0. | 0. | 4. | 16. | 0.000000 | 44.200618 | .000609 | 0.000000 |
| 2 | .041 | 1. | 1. | 2. | 14. | .000010 | 29.467079 | .000630 | .002724 |
| 3 | .055 | 1. | 1. | 1. | 13. | .000010 | 22.100309 | .000640 | .002724 |
| 4 | .069 | 3. | 3. | 1. | 13. | .000031 | 17.680247 | .000640 | .008172 |
| 5 | .083 | 3. | 3. | 1. | 13. | .000031 | 14.733539 | .000640 | .008172 |
| 6 | .186 | 3. | 3. | 1. | 13. | .000031 | 6.548240 | .000640 | .008172 |
| 7 | .359 | 5. | 5. | 1. | 13. | .000052 | 3.400048 | .000640 | .013620 |
| 8 | .703 | 9. | 10. | 1. | 13. | .000103 | 1.733358 | .000640 | .027240 |
| 9 | 1.379 | 16. | 17. | 1. | 12. | .000175 | .884012 | .000650 | .046307 |
| 10 | 2.068 | 41. | 42. | 0. | 11. | .000434 | .589342 | .000661 | .114406 |
| 11 | 3.068 | 50. | 52. | 0. | 10. | .000537 | .397309 | .000671 | .141646 |
| 12 | 3.447 | 52. | 54. | 0. | 10. | .000557 | .353605 | .000671 | .147093 |
| 13 | 4.137 | 55. | 58. | 0. | 9. | .000599 | .294671 | .000681 | .157989 |
| 14 | 6.205 | 58. | 62. | 0. | 8. | .000640 | .196447 | .000692 | .168885 |
| 15 | 6.895 | 58. | 63. | 0. | 7. | .000650 | .176802 | .000702 | .171609 |
| 16 | 13.789 | 61. | 68. | 0. | 5. | .000702 | .088401 | .000723 | .185229 |
| 17 | 20.684 | 61. | 68. | 0. | 5. | .000702 | .058934 | .000723 | .185229 |
| 18 | 27.579 | 61. | 69. | 0. | 4. | .000712 | .044201 | .000733 | .187953 |
| 19 | 34.474 | 63. | 72. | 0. | 4. | .000743 | .035360 | .000733 | .196125 |
| 20 | 41.368 | 63. | 72. | 0. | 3. | .000743 | .029467 | .000743 | .196125 |
| 21 | 48.263 | 63. | 73. | 0. | 3. | .000754 | .025257 | .000743 | .198849 |
| 22 | 103.421 | 63. | 75. | 0. | 0. | .000774 | .011787 | .000774 | .204296 |

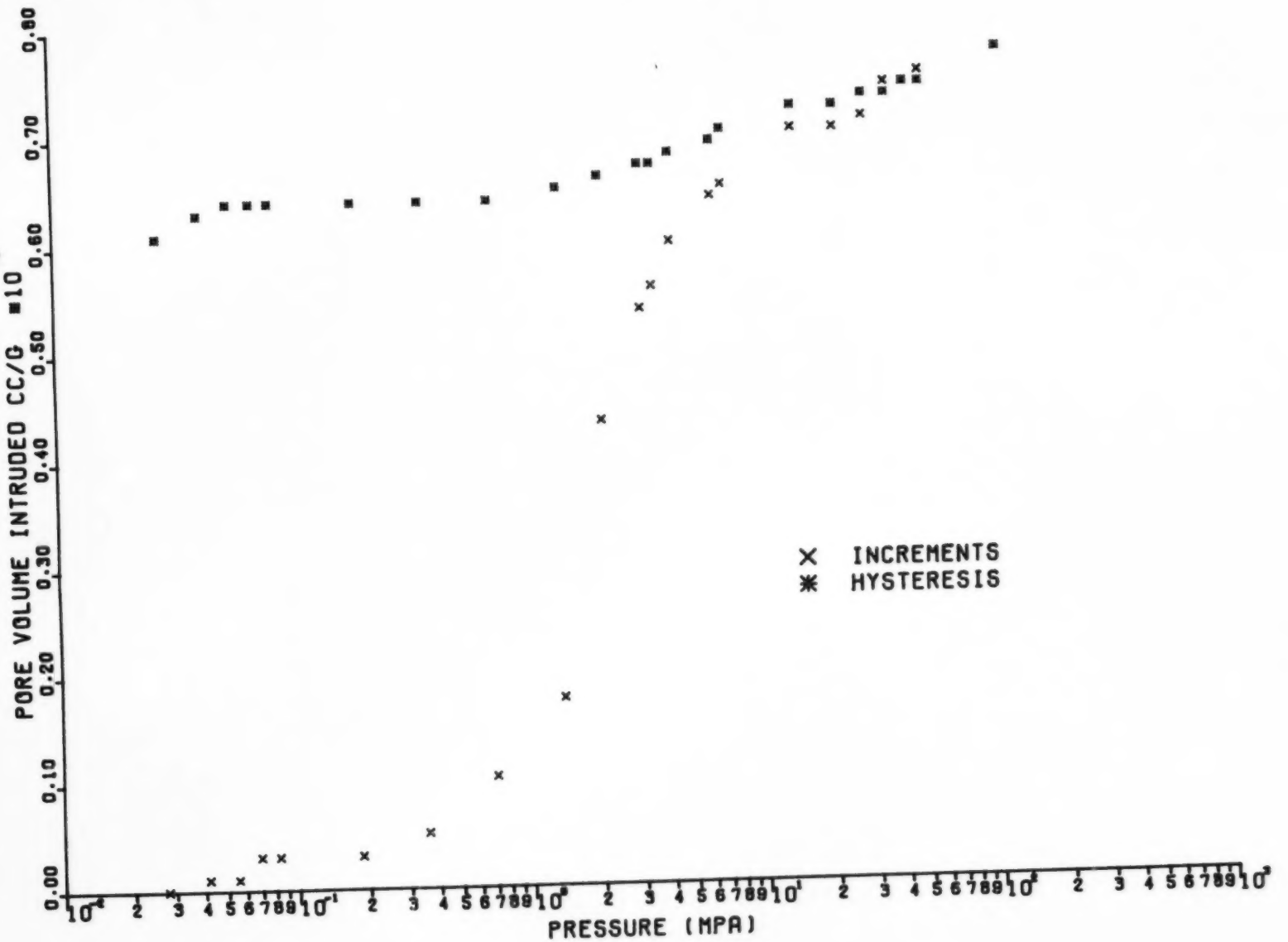


Fig. 1A. - Pressure vs pore volume graphs plotted by CAL1051 CALCOMP plotter for sample WN1 390.6

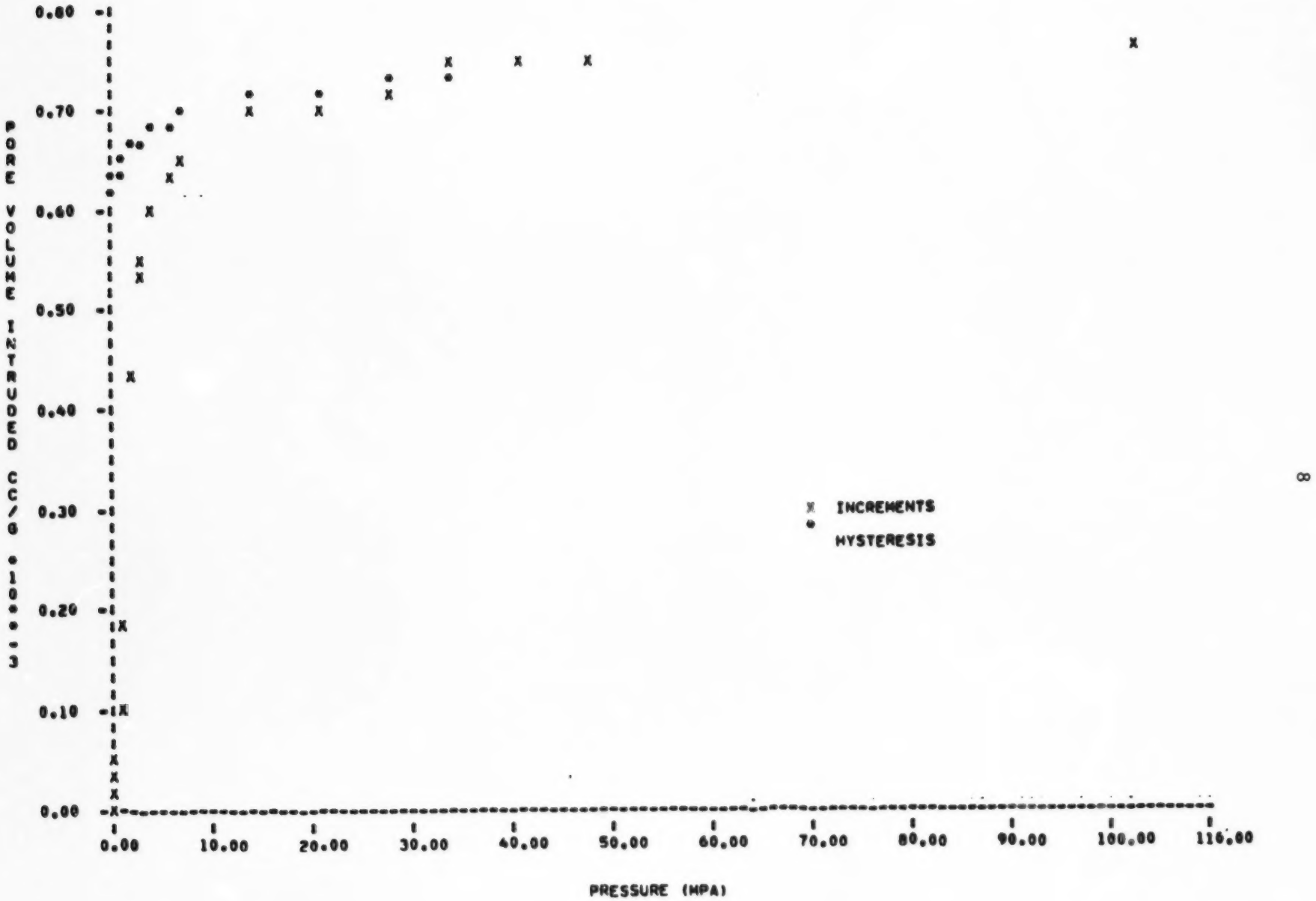


Fig. 2A. - Pressure vs pore volume graphs plotter by PRINTERPLOT for sample WN1 390.6

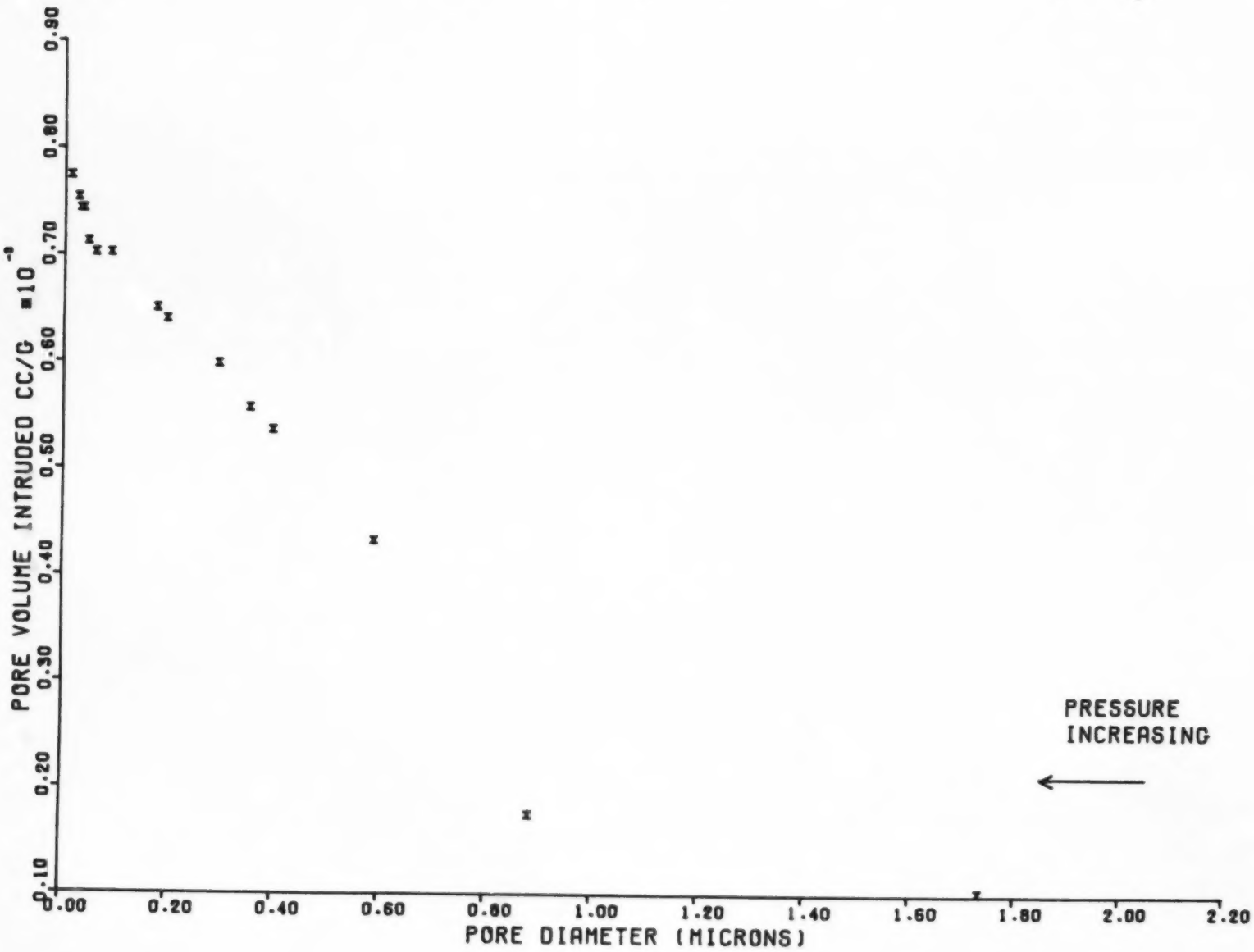


Fig. 1B. - Pore volume vs pore diameter graph plotted by CAL1050 CALCOMP plotter for sample WN1 390.6

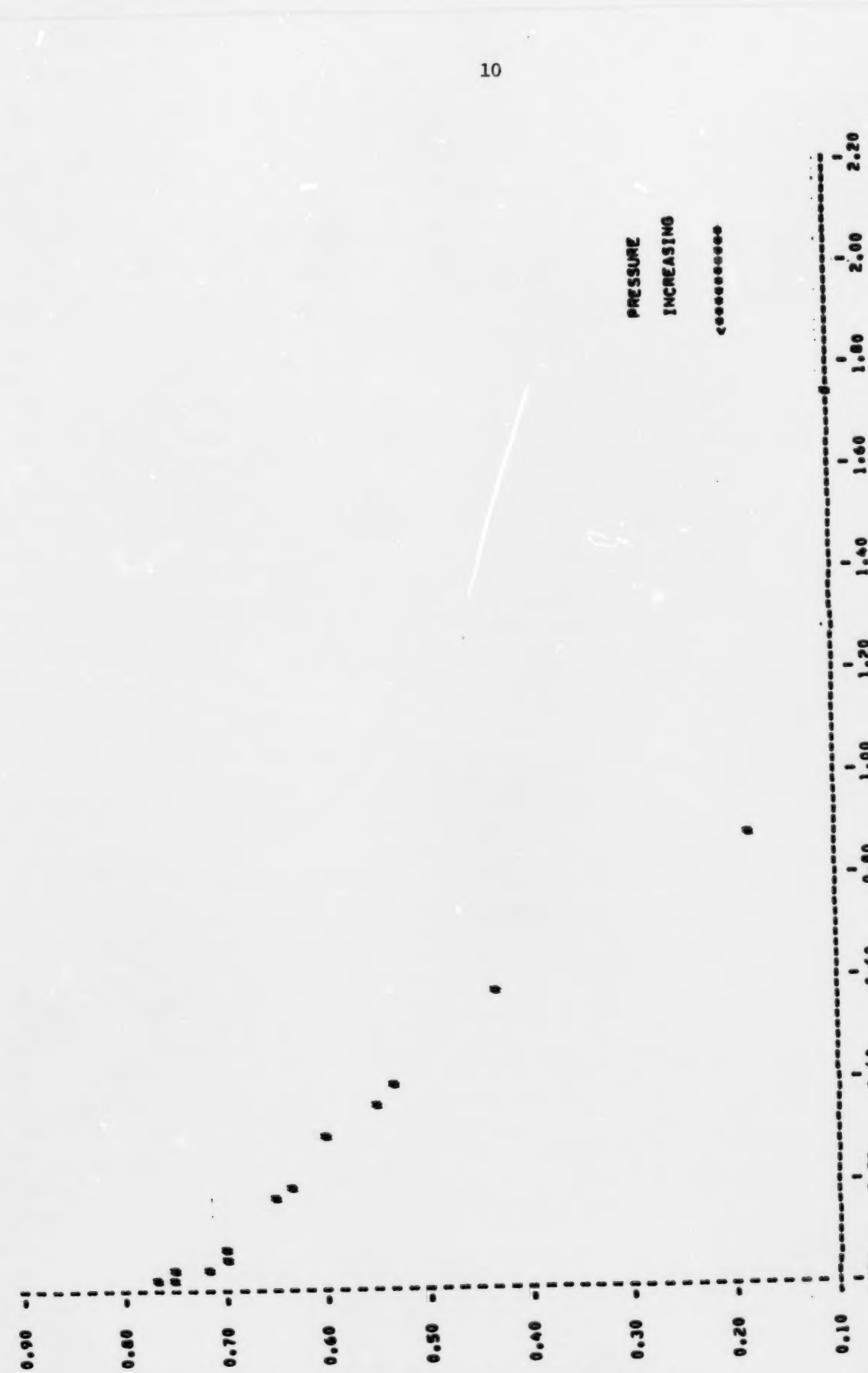


Fig. 2B. - Pore volume vs pore diameter graph plotted by PRINTER PLOT for sample WN1 390.6

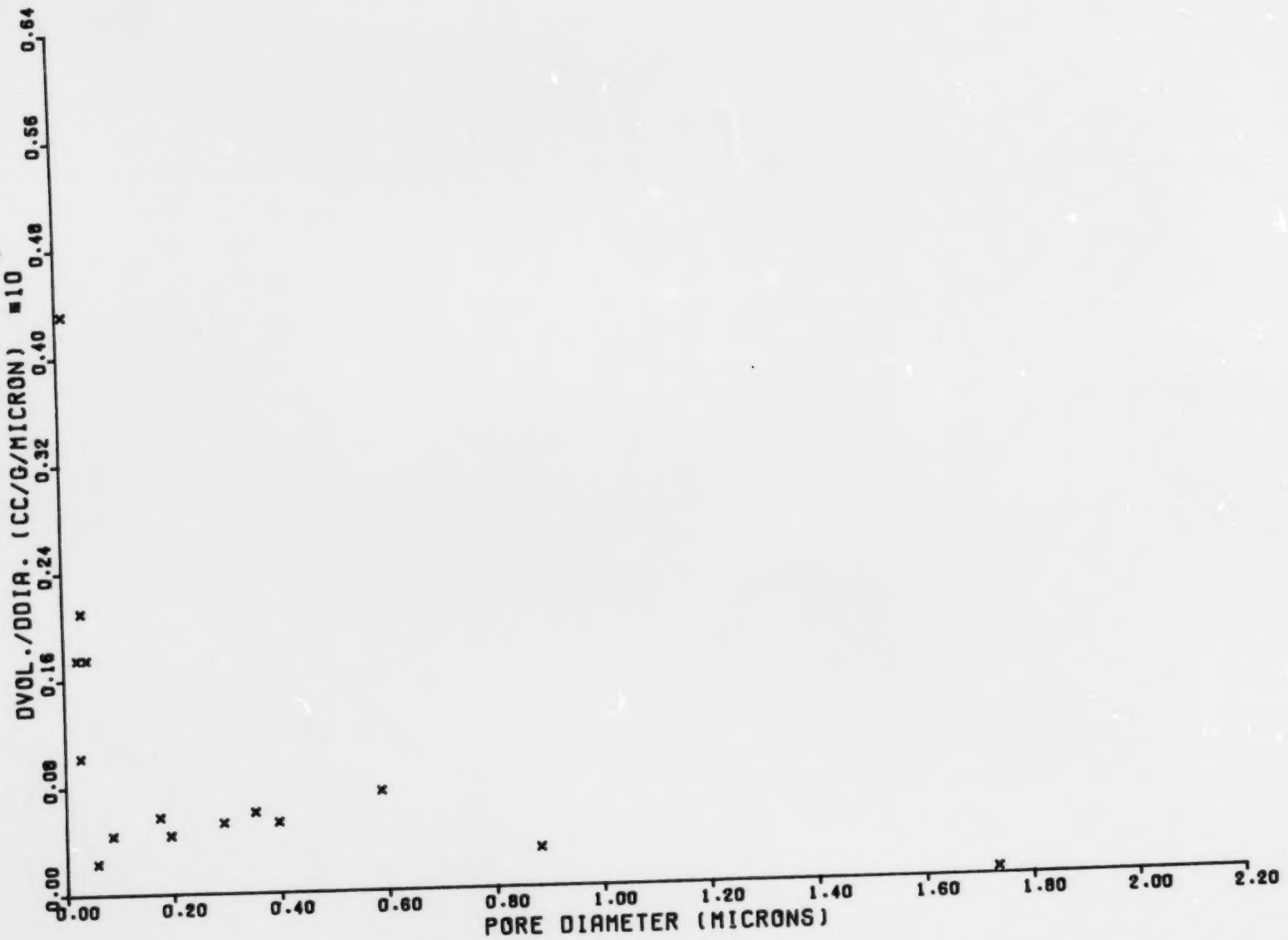


Fig. 1C. - Pore size distribution curve plotted by CAL1051 CALCOMP plotter for sample WN1 390.6

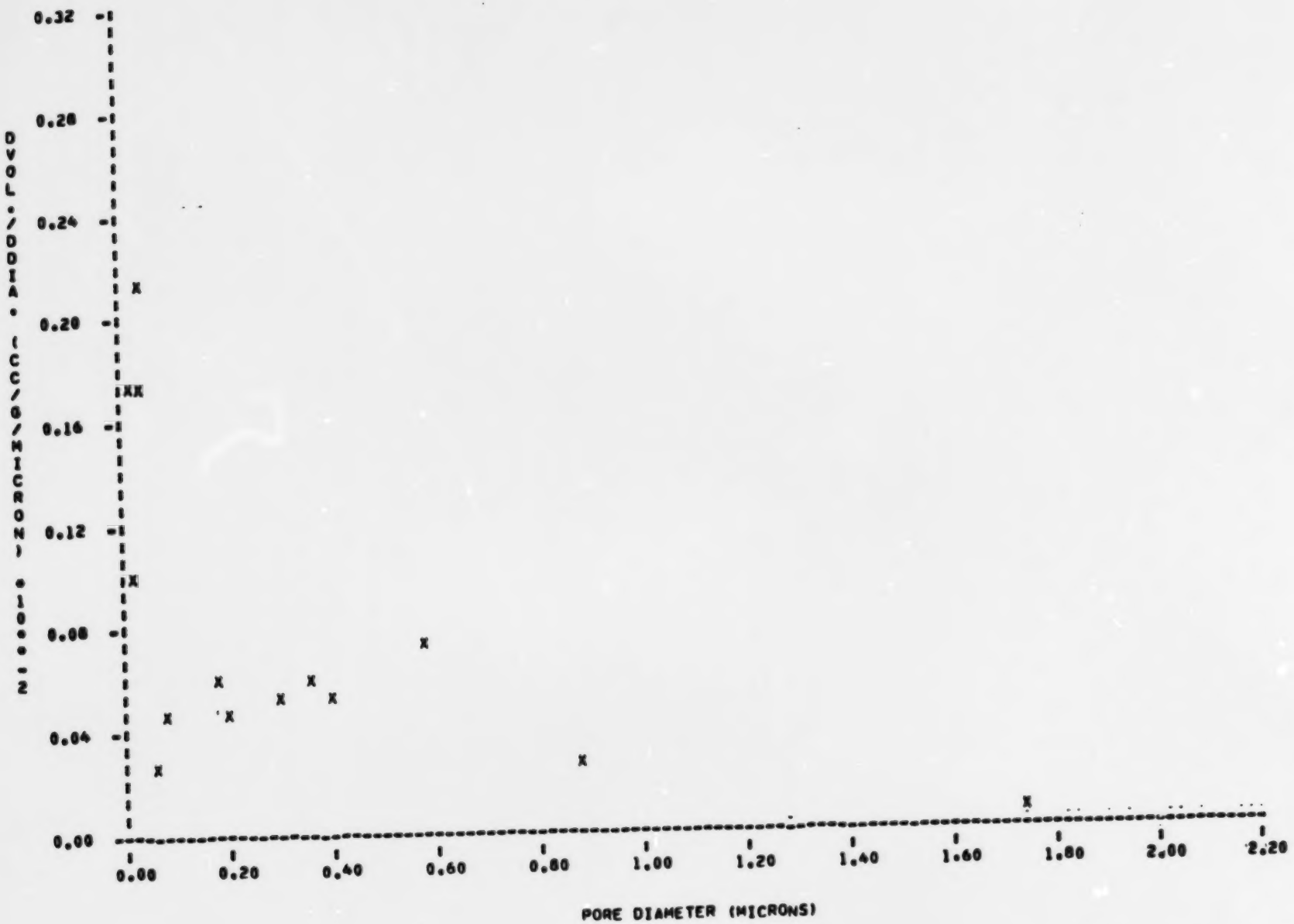


Fig. 2C. - Pore size distribution curve plotted by PRINTERPLOT for sample WN1 390.6

Many explanatory comments have been inserted throughout MERCURY with the hope that the "running commentary" will enable a person unfamiliar with the program to understand it on the basis of a source listing.

## 2.2. The Correction Function

The external function used to correct the count and hysteresis readings combines three factors; the compression of the Pyrex cell and mercury under pressure, sample compression, and mercury not compressed because the rock sample displaces it.

The number of counts due to mercury and cell compression is measured prior to porosimeter runs by doing three "blank" runs, without a sample. The volume change of the mercury-filled cell is assumed to be linearly related to pressure, and linear regression is used to find the slope and intercept of this function, for each different cell used. The parameters of the compression function become input parameters of MERCURY, and allow the first correction to be calculated;

$$C_1 = mP + b \qquad \text{Eq 4}$$

where $C_1$ = correction 1 (counts)
$m$ = slope (counts/MPa)
$b$ = intercept (counts)
$P$ = pressure (MPa).

The second correction accounts for the apparent intrusion volume due to compression of the sample. This is calculated using input values of Poisson's ratio and Young's modulus for the rock;

$$C_2 = \Delta Vs = 3(1-2\mu)(\Delta P/E)\, Vs \qquad \text{Eq 5}$$

where $C_2$ = correction 2 (cc)
$V_s$ = sample volume (cc)
$\mu$ = Poisson's ratio
$\Delta P$ = change in pressure (MPa)
$E$ = Young's modulus (MPa).

The third factor in the correction function makes an allowance for the amount of Mercury not compressed because it is displaced by the sample. It is, in effect, a correction to the first factor, $C_1$, in which the entire cell is assumed full of mercury. $C_3$ is calculated using the compressibility of mercury;

$$C_3 = \Delta V_m = K\,(P)(V_s) \qquad \text{Eq 6}$$

where $C_3$ = correction 3 (cc)
$\Delta V_m$ = change in mercury volume due to pressure
K = compressibility of mercury ($MPa^{-1}$)
P = pressure (MPa)
$V_s$ = sample volume = volume of displaced mercury (cc).

Compressibility is linearly related to pressure; from a table of pressure vs compressibility values (using only pressures less than the maximum 103 MPa reached in most experimental runs), a slope and intercept were found by linear regression;

$$K = 4\text{x}10^{-5} - 1.021 \text{ x } 10^{-8}(P) \qquad \text{Eq 7}$$

Thus equation 6 becomes

$$C_3 = (4\text{x}10^{-5} - 1.021\text{x}10^{-8}(P))(P)(V_s) \qquad \text{Eq 8}$$

At each pressure reading, $C_2$ and $C_3$ are converted to counts and the three counts are algebraically summed. The total correction thus obtained is rounded to an integer, since only whole counts can be recorded on a porosimeter such as the one used.

2.3. Mercury Input Description

A. Card No. 1
READ, NRUN
FORMAT (I5)
NRUN - number of samples to be analysed

B. Block of cards for each sample

a. READ, W, SAWT, SADIA, SAHT, W1, WT, CT, NUM, CLAMP, SAWT2

FORMAT, (A10, 6F10.0, I10/2F10.0)

W - sample identification

SAWT - weight of sample (g)

SADIA - diameter of sample (cm)

SAHT - height of sample (cm)

W1 - weight of sample + cell + grease seal (g)

WT - W1 + mercury weight + CLAMP (g)

CT - displacement count

NUM - number of readings

CLAMP - weight of the clamp (g)

SAWT2 - sample weight after test (g)

b. READ, VCELL, FACT, SLOPE, INT, V, MOD

FORMAT (6F10.0)

VCELL - volume of the sample cell (cc)

FACT - cell factor (cc/count)

SLOPE - blank run slope (counts/psi)

INT - intercept of blank run (counts)

V - Poisson's ratio

MOD - Young's modulus (MPa)

c. READ, IOPT1, IOPT2, IOPT3, IOPT4, II

FORMAT (4I1, I2)

IOPT1 - Output control indicator

= 0 print output

≠ 0 no print of output

IOPT2 - Pressure vs intrusion plot indicator

= 0 graph plotted

≠ 0 no plot

IOPT3 - Pore volume vs pore diameter plot indicator

= 0 graph plotted

≠ 0 no plot

IOPT4 - Pore size distribution plot indicator

= 0 graph plotted

≠ no plot

II - number of initial data points to be erased for IOPT3 and IOPT4 plots.

d. There will be 'NUM' cards for the sample.

READ, PSI(NUM), C(NUM), HYS(NUM)

FORMAT (F7.1, 2F4.0)

PSI - pressure (psi)

HYS - hysteresis count

## 2.4 Example of MERCURY Input

The control cards with an example of input data to execute MERCURY is given in Fig. 3.

## 2.5 MERCURY Output

Typical MERCURY outputs are given in Tables 1A, 1B and 1C and graphs produced by CALCOMP plotter are given in Figs. 1A, 1B and 1C and Figs. 2A, 2B and 2C are produced by PRINTERPLOT.

```
H1234,CM73000,T70,I0300,J2.              MERCURY TEST EXAMPLE
ACCOUNT(12345)
ATTACH(OLDPL,MERCURY,ID=GORSKI)
ATTACH(PLTSIM,PLOTSIMLIB,ID=MRL,MR=1)
LIBRARY(PLTSIM)
UPDATE(C=MERCS)
FTN(I=MERCS,B=MERC,L=0)
PLTPAR(DEVICE=CAL1051,NAME=$ NAME $,P1=NIB,P2=NIB,C2=BLACK,S1=2,S2=4)
MERC.
7/8/9                MULTIPLE PUNCH IN COLUMN ONE
*C MERC
7/8/9                MULTIPLE PUNCH IN COLUMN ONE
    1
WN1 390.60      37.20      2.470      2.982      81.97     264.85        72.          22
     39.62      37.46
     24.71    .000384    .004281    -5.4175        .26     71000.
0000 7
     2.   0.   4.
     4.   1.   2.
     6.   1.   1.
     8.   3.   1.
    10.   3.   1.
    25.   3.   1.
    50.   5.   1.
   100.   9.   1.
   200.  16.   1.
   300.  41.   0.
   445.  50.   0.
   500.  52.   0.
   600.  55.   0.
   900.  58.   0.
  1000.  58.   0.
  2000.  61.   0.
  3000.  61.   0.
  4000.  61.   0.
  5000.  63.   0.
  6000.  63.   0.
  7000.  63.   0.
 15000.  63.   0.
7/8/9                MULTIPLE PUNCH IN COLUMN ONE
6/7/8/9              MULTIPLE PUNCH IN COLUMN ONE
```

Note: Device defines the device on which the plot is to be carried out. Either CAL1051, PRNTPLT or CAL960 can be specified.

Fig. 3 - Control cards with an example of input data to execute MERCURY.

## 3. BIBLIOGRAPHY

1. CSC User's Guide, revision D, prepared by Customer Service Division Computer Science Centre, Department of Energy, Mines and Resources, Ottawa; July 1980.

2. Mercury Penetration Porosimeter Model 900/910 Series Instruction Manual, prepared by Micromeritics Corp., Noroross , Ga.; December 1976.

3. Molson, John, "A computer program technique for mercury porosimetry studies", MRL Report 81-96 (TR); August, 1981.

# APPENDIX A

## FORTRAN LISTING OF MERCURY

```
      PROGRAM MERC(INPUT,OUTPUT,TAPE5=INPUT)                                MERC     2
C                                                                           MERC     3
C     THIS PROGRAM READS IN DATA FROM A MERCURY POROSIMETER AND EXECUTES    MERC     4
C     THE REQUIRED CALCULATIONS.  OPTIONAL PLOTTING ROUTINES ARE            MERC     5
C     AVAILABLE.                                                            MERC     6
C                                                                           MERC     7
C     PRESSURE VALUES ARE READ AS LBS. PER SQ. INCH BUT ARE CONVERTED       MERC     8
C     IMMEDIATELY TO MEGAPASCALS.  WEIGHTS AND LENGTHS ARE ENTERED IN       MERC     9
C     GRAMS AND CENTIMETRES RESPECTIVELY.  SLOPE OF BLANK RUN IS ENTERED    MERC    10
C     IN COUNTS PER PSI AND CONVERTED TO COUNTS PER MEGAPASCALS.            MERC    11
C                                                                           MERC    12
C     VARIABLES USED:                                                       MERC    13
C                                                                           MERC    14
C     INPUT VARIABLES                                                       MERC    15
C                                                                           MERC    16
C     C - COUNT                                                             MERC    17
C     CLAMP - WEIGHT OF THE CLAMP  (G)                                      MERC    18
C     CT - DISPLACEMENT COUNT                                               MERC    19
C     FACT - CELL FACTOR  (CC/COUNT)                                        MERC    20
C     HYS - HYSTERESIS COUNT                                                MERC    21
C     II - NUMBER OF INITIAL DATA POINTS TO BE ERASED FOR FINAL PLOT        MERC    22
C     INT - INTERCEPT OF BLANK RUN  (COUNTS)                                MERC    23
C     IOPT1,2,3,4 - OPTIONS FOR OUTPUT                                      MERC    24
C     MOD - YOUNG'S MODULUS  (MEGAPASCALS)                                  MERC    25
C     NRUN - NUMBER OF SAMPLES TO BE ANALYSED                               MERC    26
C     NUM - NUMBER OF READINGS                                              MERC    27
C     PLTYPE - A CHARACTER VARIABLE DEFINED IN THE CONTROL CARDS            MERC    28
C              WHICH INDICATES PLOTTING DEVICE BEING USED                   MERC    29
C     PSI - PRESSURE  (LBS/SQ. INCH)                                        MERC    30
C     SADIA - DIAMETER OF SAMPLE  (CM)                                      MERC    31
C     SAHT - HEIGHT OF SAMPLE  (CM)                                         MERC    32
C     SAWT -WEIGHT OF SAMPLE  (G)                                           MERC    33
C     SAWT2 - SAMPLE WT. AFTER TEST  (G)                                    MERC    34
C     SLOPE - BLANK RUN SLOPE  (COUNTS/PSI)                                 MERC    35
C     V - POISSON'S RATIO                                                   MERC    36
C     VCELL - VOLUME OF THE TEST CELL  (CC)                                 MERC    37
C     W - SAMPLE IDENTIFICATION                                             MERC    38
C     WT - W1 + HG + CLAMP      (G)                                         MERC    39
C     W1 - WEIGHT OF SAMPLE + CELL + GREASE SEAL    (G)                     MERC    40
C                                                                           MERC    41
C     VARIABLES USED IN THE PROGRAM                                         MERC    42
C                                                                           MERC    43
C     CONST1,CONST2 - CONSTANTS DETERMINED BY THE DATA, AND USED IN         MERC    44
C                     THE CALCULATION OF INTRUSION VOLUME, POROSITY, AND    MERC    45
C                     HYSTERESIS VOLUME.                                    MERC    46
C     CORRCT - CORRECTION COUNT, DETERMINED BY CALLING AN EXTERNAL          MERC    47
C              FUNCTION, CORR                                               MERC    48
C     DIAS - A STORE ARRAY FOR DIA  (MICRONS)                               MERC    49
C     DV - DIFFERENTIAL VOLUME  (CC/G/MICRON)                               MERC    50
C     HG - WEIGHT OF THE MERCURY IN THE CELL, AFTER THE RUN  (G)            MERC    51
C     IPLT - A COUNT OF THE GRAPHS PLOTTED                                  MERC    52
C     NRUND - A DEFAULT VALUE FOR NRUN                                      MERC    53
C     STORE,STORE2 - STORAGE VARIABLES FOR NUM                              MERC    54
C     VOLHG - VOLUME OF THE MERCURY REMAINING IN THE CELL  (CC)             MERC    55
C     VOLS - STORAGE ARRAY FOR VOL  (CC/G)                                  MERC    56
C     VOLSA - VOLUME OF SAMPLE MEASURED BY HG DISPLACEMENT  (CC)            MERC    57
C                                                                           MERC    58
```

```
      C     OUTPUT VARIABLES                                                  MERC       59
      C                                                                       MERC       60
   60 C     CC - CORRECTED COUNT                                              MERC       61
      C     DBYHG - DENSITY CALCULATED USING SAMPLE WEIGHT AND VOLUME BY HG   MERC       62
      C             DISPLACEMENT  (G/CC)                                      MERC       63
      C     DIA - PORE DIAMETER  (MICRONS)                                    MERC       64
      C     DMEAS - DENSITY, DETERMINED USING DIMENSIONS AND                  MERC       65
   65 C             SAMPLE WEIGHT  (G/CC)                                     MERC       66
      C     DTRUE - SKELETAL DENSITY  (G/CC)                                  MERC       67
      C     H2 - HYSTERESIS CORRECTED COUNT                                   MERC       68
      C     MPA - PRESSURE  (MEGAPASCALS)                                     MERC       69
      C     P - POROSITY  (%)                                                 MERC       70
   70 C     PMAX - PEAK VALUE OF THE MEASURED POROSITY  (%)                   MERC       71
      C     VOL - INTRUSION VOLUME  (CC/G)                                    MERC       72
      C     VV - HYSTERESIS VOLUME  (CC/G)                                    MERC       73
      C                                                                       MERC       74
            EXTERNAL CORR                                                     MERC       75
   75       REAL P(40),VOL(40),C(40),CC(40),PSI(40),HYS(40),DIA(40),H2(40),   MERC       76
           1VV(40),DV(40),MPA(40),CORRCT(40),VOLS(40),DIAS(40)                MERC       77
            REAL MOD,INT                                                      MERC       78
            COMMON/PLTBUF/IBUF(1025)                                          MERC       79
            INTEGER PLTYPE,IPEN(2),STORE,STORE2                               MERC       80
   80       DATA IPEN/1,2/                                                    MERC       81
      C                                                                       MERC       82
      C     INITIALIZE PLOT COUNT AND SET ORIGIN FOR PLOTS.                   MERC       83
      C                                                                       MERC       84
            IPLT=0                                                            MERC       85
   85       XLNG=15.0                                                         MERC       86
            XINT=1.5                                                          MERC       87
            YINT=2.0                                                          MERC       88
      C                                                                       MERC       89
      C     INPUT NUMBER OF SAMPLES TO BE ANALYSED.  LET THE DEFAULT BE ONE.  MERC       90
   90 C     IF A BLANK CARD IS ENCOUNTERED.                                   MERC       91
      C                                                                       MERC       92
            NRUND=1                                                           MERC       93
            READ (5,500) NRUN                                                 MERC       94
        500 FORMAT (I5)                                                       MERC       95
   95       IF (NRUN.EQ.0) NRUN=NRUND                                         MERC       96
            DO 185 IJ=1,NRUN                                                  MERC       97
      C                                                                       MERC       98
      C     ENTER DATA PERTAINING TO THE ROCK SAMPLE AND THE RUN.             MERC       99
      C                                                                       MERC      100
  100       READ (5,1000) W,SAWT,SADIA,SAHT,W1,WT,CT,NUM,CLAMP,SAWT2          MERC      101
       1000 FORMAT (A10,6F10.0,I10/2F10.0)                                    MERC      102
            PRINT 1100, W,SAWT,SADIA,SAHT,W1,WT,CT,CLAMP,SAWT2,NUM            MERC      103
       1100 FORMAT (1H1,10(/),15X,"******  INPUT DATA INFORMATION  ******",//,  MERC      104
           1        1H ,10X,"SAMPLE IDENTIFICATION              = ",A10,/,    MERC      105
  105      2        1H ,10X,"WEIGHT OF SAMPLE (G)               = ",F10.4,/,  MERC      106
           3        1H ,10X,"DIAMETER OF SAMPLE (CM)            = ",F10.4,/,  MERC      107
           4        1H ,10X,"HEIGHT OF SAMPLE (CM)              = ",F10.4,/,  MERC      108
           5        1H ,10X,"SAMPLE WT. +CELL+GREASE SEAL (G)   = ",F10.4,/,  MERC      109
           6        1H ,10X,"SAMPLE WT. + HG + CLAMP (G)        = ",F10.4,/,  MERC      110
  110      7        1H ,10X,"DISPLACEMENT COUNT                 = ",F10.4,/,  MERC      111
           8        1H ,10X,"WEIGHT OF CLAMP (G)                = ",F10.4,/,  MERC      112
           9        1H ,10X,"SAMPLE WT. AFTER TEST (G)          = ",F10.4,/,  MERC      113
           $        1H ,10X,"NUMBER OF READINGS                 = ",I10)      MERC      114
            STORE=NUM                                                         MERC      115
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      READ (5,1200) VCELL,FACT,SLOPE,INT,V,MOD                          MERC  116
 1200 FORMAT (6F10.0)                                                   MERC  117
      PRINT 1300, VCELL,FACT,SLOPE,INT,V,MOD                            MERC  118
 1300 FORMAT (1H ,10X,"VOL. OF HG POROSIMETER CELL (CC) = ",F10.4,/,    MERC  119
     1        1H ,10X,"CELL FACTOR (CC/COUNT)          = ",F10.4,/,     MERC  120
     2        1H ,10X,"BLANK RUN SLOPE (COUNT/PSI)     = ",F10.4,/,     MERC  121
     3        1H ,10X,"INTERCEPT OF BLANK RUN (COUNTS) = ",F10.4,/,     MERC  122
     4        1H ,10X,"POISSON'S RATIO                 = ",F10.4,/,     MERC  123
     5        1H ,10X,"YOUNG'S MODULUS (MPA)           = ",E15.7)       MERC  124
C                                                                       MERC  125
C     READ THE FOUR OPTIONS FOR OUTPUT.  IF THE VALUE OF THE IOPT# IS   MERC  126
C     ONE, THIS INDICATES THAT THE CORRESPONDING OUTPUT IS DESIRED.     MERC  127
C     IOPT1 REFERS TO THE TABLE, IOPT2 TO THE LOG PLOT OF PRESSURE      MERC  128
C     VERSUS INTRUSION, IOPT3 TO THE PLOT OF PORE VOLUME VERSUS PORE    MERC  129
C     DIAMETER, AND IOPT4 TO THE PORE DISTRIBUTION GRAPH.   II IS THE   MERC  130
C     NUMBER OF INITIAL POINTS, AT LOW PRESSURES, TO BE ERASED FOR THE  MERC  131
C     SECOND AND FINAL PLOTS, TO YIELD A CLEARER RANGE OF VALUES.       MERC  132
C                                                                       MERC  133
      READ (5,1400) IOPT1,IOPT2,IOPT3,IOPT4,II                          MERC  134
 1400 FORMAT (4I1,I2)                                                   MERC  135
C                                                                       MERC  136
C     INDICATE WHAT OUTPUT HAS BEEN REQUESTED, AND PRINT II, THE        MERC  137
C     NUMBER OF INITIAL POINTS DELETED.                                 MERC  138
C                                                                       MERC  139
      IF (IOPT2.EQ.0.AND.IOPT3.EQ.0.AND.IOPT4.EQ.0) PRINT 1500          MERC  140
 1500 FORMAT (1H0,10X,"NO GRAPH IS PLOTTED")                            MERC  141
      IF (IOPT2.NE.0) PRINT 1600                                        MERC  142
 1600 FORMAT (1H0,10X,"A PRESSURE VS. INTRUSION GRAPH IS PLOTTED")      MERC  143
      IF (IOPT3.NE.0) PRINT 1700, II                                    MERC  144
 1700 FORMAT (1H0,10X,"A PORE VOLUME VS. PORE DIAMETER GRAPH IS PLOTTED MERC  145
     1AND ",I2," INITIAL DATA POINTS ARE ERASED FROM THE PLOT")          MERC  146
      IF (IOPT4.NE.0) PRINT 1800, II                                    MERC  147
 1800 FORMAT (1H0,10X,"A PORE SIZE DISTRIBUTION GRAPH IS PLOTTED AND ",I MERC  148
     12," INITIAL DATA POINTS ARE ERASED FROM THE PLOT")                MERC  149
C                                                                       MERC  150
C     CALCULATE  THE VOLUME OF MERCURY REMAINING IN THE CELL, AND THEN  MERC  151
C     THE SAMPLE VOLUME BY MERCURY DISPLACEMENT.                        MERC  152
C                                                                       MERC  153
      VOLHG=(WT-W1-CLAMP)/13.534                                        MERC  154
      VOLSA=VCELL-(CT*FACT)-VOLHG                                       MERC  155
C                                                                       MERC  156
C     ENTER PRESSURE, COUNT AND HYSTERESIS DATA FOR THE RUN.            MERC  157
C                                                                       MERC  158
      DO 10 J=1,NUM                                                     MERC  159
      READ (5,1900) PSI(J),C(J),HYS(J)                                  MERC  160
      IF (EOF(5).NE.0.0) GO TO 200                                      MERC  161
 1900 FORMAT (F7.1,2F4.0)                                               MERC  162
C                                                                       MERC  163
C     ADD HG HEAD PRESSURE IF PSI IS LESS THAN OR EQUAL TO 100, AND     MERC  164
C     CONVERT TO MPA.                                                   MERC  165
C                                                                       MERC  166
      IF (PSI(J).LE.100) PSI(J)=PSI(J)+2.                               MERC  167
      MPA(J)=PSI(J)*6.8947E-3                                           MERC  168
   10 CONTINUE                                                          MERC  169
C                                                                       MERC  170
C     CONVERT SLOPE OF BLANK RUN FROM COUNTS/PSI TO COUNTS/MPA.         MERC  171
C                                                                       MERC  172
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      SLOPE=SLOPE*145.                                                  MERC  173
                                                                        MERC  174
C                                                                       MERC  175
C     CORRECT THE COUNTS FOR RISING PRESSURE, AND CALCULATE THE         MERC  176
C     INTRUSION VOLUME, THE PORE DIAMETERS, AND THE POROSITY            MERC  177
C     CORRESPONDING TO EACH PRESSURE INCREMENT.  SET UP A CHECK VARIABLE MERC  178
C     TO PICK OUT THE PEAK VALUE FOR POROSITY.                          MERC  179
C                                                                       MERC  180
      PMAX=0.                                                           MERC  181
      CONST1=FACT/SAWT                                                  MERC  182
      CONST2=FACT*100./VOLSA                                            MERC  183
      DO 20 J=1,NUM                                                     MERC  184
      CORRCT(J)=CORR(INT,SLOPE,HPA(J),VOLSA,MOD,V,FACT)                 MERC  185
      CC(J)=IFIX(C(J)-CORRCT(J)+0.5)                                    MERC  186
      VOL(J)=CC(J)*CONST1                                               MERC  187
      DIA(J)=1.219/HPA(J)                                               MERC  188
      P(J)=CC(J)*CONST2                                                 MERC  189
      VOLS(J)=VOL(J)                                                    MERC  190
      DIAS(J)=DIA(J)                                                    MERC  191
      IF (PMAX.LT.P(J)) PMAX=P(J)                                       MERC  192
   20 CONTINUE                                                          MERC  193
C                                                                       MERC  194
C     CALCULATE CORRECTED HYSTERESIS COUNTS AND HYSTERESIS VOLUMES.     MERC  195
C                                                                       MERC  196
      DO 30 K=1,NUM                                                     MERC  197
      H2(K)=IFIX(HYS(K)-CORRCT(NUM)+CORRCT(K)+0.5)                      MERC  198
      VV(K)=(CC(NUM)-H2(K))*CONST1                                      MERC  199
   30 CONTINUE                                                          MERC  200
C                                                                       MERC  201
C     IF THE TABLE IS REQUESTED,PRINT THE HEADINGS.  OTHERWISE BYPASS   MERC  202
C     THIS SECTION, AND GO TO THE PLOTTING ROUTINES.                    MERC  203
C                                                                       MERC  204
      IF (IOPT1.EQ.0) GO TO 50                                          MERC  205
      PRINT 2000, W                                                     MERC  206
 2000 FORMAT (1H1,40X,"SAMPLE IDENTIFICATION",5X,A10)                   MERC  207
      PRINT 2100                                                        MERC  208
 2100 FORMAT (1H0,4X,"NO.",4X,"PRESSURE",4X,"COUNT",4X,"CORRECTED",3X,  MERC  209
     1  "HYSTERESIS",2X,"CORRECTED",3X,"INTRUSION",7X,"PORE DIA.",     MERC  210
     2  7X,"HYS VOL.",7X,"POROSITY")                                   MERC  211
      PRINT 2200                                                        MERC  212
 2200 FORMAT (13X,"(MPA)",16X,"COUNT",8X,"COUNT",5X,"HYS COUNT",5X,     MERC  213
     1  "(CC/G)",8X,"(MICRONS)",8X,"(CC/G)",7X,"(PERCENT)")            MERC  214
C                                                                       MERC  215
C     PRINT DATA                                                        MERC  216
C                                                                       MERC  217
      DO 40 K=1,NUM                                                     MERC  218
      PRINT 2300, K,HPA(K),C(K),CC(K),HYS(K),H2(K),VOL(K),DIA(K),VV(K),P MERC  219
     1(K)                                                               MERC  220
 2300 FORMAT (1H0,5X,I2,F12.3,F9.0,3F12.0,2X,F11.6,3X,F13.6,3X,F12.6,3X, MERC  221
     1  F12.6)                                                         MERC  222
   40 CONTINUE                                                          MERC  223
C                                                                       MERC  224
C     CALCULATE DENSITY BY MEASUREMENT, DENSITY BY MERCURY DISPLACEMENT, MERC  225
C     AND SKELETAL DENSITY.  PRINT THESE VALUES.                        MERC  226
C                                                                       MERC  227
      DMEAS=SAWT/(3.14159*(SADIA/2.)**2*SAHT)                           MERC  228
      DBYHG=SAWT/VOLSA                                                  MERC  229
      DTRUE=DBYHG*100./(100.-PMAX)
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      PRINT 2400, DMEAS,DBYHG,DTRUE,PMAX                                    MERC      230
                                                                            MERC      231
230   2400 FORMAT (1H1,/,                                                   MERC      232
     1  1H0,10X,"BULK DENSITY BY MEASUREMENT IS     = ",F10.4," (G/CC)",/   MERC      233
     2, 1H ,10X,"DENSITY BY HG DISPLACEMENT IS     = ",F10.4," (G/CC)",/   MERC      234
     3, 1H ,10X,"SKELETAL DENSITY IS               = ",F10.4" (G/CC)",/    MERC      235
     4, 1H ,10X,"POROSITY OF THE SAMPLE IS         = ",F10.4," ( % )")     MERC      236
235   C                                                                     MERC      237
      C     IF NONE OF THE PLOTS ARE REQUESTED, BYPASS THE ROUTINES.        MERC      238
      C                                                                     MERC      239
        50 IF (IOPT2.EQ.0.AND.IOPT3.EQ.0.AND.IOPT4.EQ.0) GO TO 185          MERC      240
      C                                                                     MERC      241
240   C     INITIALIZE PLOT, ACCORDING TO PLOT TYPE (I.E. PRNTPLT OR CAL1051) MERC      242
      C     AND PLOT COUNT, IPLT.                                           MERC      243
      C                                                                     MERC      244
            IF (IPLT.NE.0) GO TO 55                                         MERC      245
            CALL PLOTS (IBUF,1025)                                          MERC      246
245         CALL PLOT (XINT,YINT,-3)                                        MERC      247
            CALL GETDEV (PLTYPE)                                            MERC      248
            GO TO 58                                                        MERC      249
        55  IF (PLTYPE.EQ.7LCAL1051) GO TO 56                               MERC      250
            CALL PLOTS (IBUF,1025)                                          MERC      251
250         CALL PLOT (XINT,YINT,-3)                                        MERC      252
            GO TO 58                                                        MERC      253
        56  IF (IPLT.NE.0) CALL PLOT (XINT+XLNG,0.0,-3)                     MERC      254
        58  CALL NEWPEN (IPEN(1))                                          MERC      255
      C                                                                     MERC      256
255   C     LOGARITHMIC PLOT . PRESSURE VS. INTRUSION                       MERC      257
      C                                                                     MERC      258
      C     IF THE FIRST PLOT HAS NOT BEEN REQUESTED, BYPASS IT.            MERC      259
            IF (IOPT2.EQ.0) GO TO 60                                        MERC      260
      C                                                                     MERC      261
260   C     SCALE X VALUES.  IF A PRINTERPLOT IS BEING PRODUCED, USE A NORMAL MERC      262
      C     AXIS.  IF A CALCOMP PLOT IS BEING GENERATED, USE A LOG AXIS.    MERC      263
            IF (PLTYPE.EQ.7LCAL1051) CALL SCALG (MPA,11.,NUM,1)             MERC      264
            IF (PLTYPE.EQ.7LPRNTPLT) CALL SCALE (MPA,11.,NUM,1)             MERC      265
            FIRSTX=MPA(NUM+1)                                               MERC      266
265         DELTAX=MPA(NUM+2)                                               MERC      267
      C     SCALE Y VALUES.                                                 MERC      268
            CALL SCALE (VOL,8.,NUM,1)                                       MERC      269
            FIRSTY=VOL(NUM+1)                                               MERC      270
            DELTAY=VOL(NUM+2)                                               MERC      271
270         CALL SCALE (VV,8.,NUM,1)                                        MERC      272
            VV(NUM+1)=FIRSTY                                                MERC      273
            VV(NUM+2)=DELTAY                                                MERC      274
      C     PLOT DATA, AXES AND HEADINGS.  DO A LOG PLOT IF A CALCOMP PLOTTING MERC      275
      C     DEVICE IS BEING USED.                                           MERC      276
            IF (PLTYPE.EQ.7LCAL1051) CALL LGLIN (MPA,VOL,NUM,1,-1,4,-1)     MERC      277
275         IF (PLTYPE.EQ.7LPRNTPLT) CALL LINE (MPA,VOL,NUM,1,-1,4)         MERC      278
            IF (PLTYPE.EQ.7LCAL1051) CALL LGLIN (MPA,VV,NUM,1,-1,11,-1)     MERC      279
            IF (PLTYPE.EQ.7LPRNTPLT) CALL LINE (MPA,VV,NUM,1,-1,11)         MERC      280
            CALL NEWPEN (IPEN(2))                                           MERC      281
280         IF (PLTYPE.EQ.7LCAL1051) CALL LGAXS (0.,0.,14HPRESSURE (MPA),-14,1 MERC      282
           11.,0.,FIRSTX,DELTAX)                                            MERC      283
            IF (PLTYPE.EQ.7LPRNTPLT) CALL AXIS (0.,0.,14HPRESSURE (MPA),-14,11 MERC      284
           1.,0.,FIRSTX,DELTAX)                                             MERC      285
            CALL AXIS (0.0,0.0,25HPORE VOLUME INTRUDED CC/G,25,8.,90.,FIRSTY,D MERC      286
285        1ELTAY)
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                CALL SYMBOL (1.0,-1.5,0.21,24HPRESSURE VS. PORE VOLUME,0.0,30)      MERC      287
                CALL SYMBOL (999.,999.,.21,W,0.0,10)                                MERC      288
                CALL SYMBOL (7.,3.,.14,4,0.0,-1)                                    MERC      289
                CALL SYMBOL (7.0,2.93,.14,13H   INCREMENTS,0.0,13)                  MERC      290
290             CALL SYMBOL (7.,2.75,.14,11,0.0,-1)                                 MERC      291
                CALL SYMBOL (7.,2.68,.14,13H   HYSTERESIS,0.0,13)                   MERC      292
                IF (PLTYPE.EQ.7LPRNTPLT) CALL PLOT (0.,0.,999)                      MERC      293
          C     INCREMENT PLOT COUNT BY ONE.                                        MERC      294
                IPLT=IPLT+1                                                         MERC      295
295       C                                                                         MERC      296
          C     PLOT OF PORE VOLUME VS. PORE DIAMETER                               MERC      297
          C                                                                         MERC      298
          C     IF THE SECOND PLOT HAS NOT BEEN REQUESTED, BYPASS IT.               MERC      299
             60 IF (IOPT3.EQ.0) GO TO 120                                           MERC      300
300       C                                                                         MERC      301
                IF (II.EQ.0) II=1                                                   MERC      302
                IF (PLTYPE.EQ.7LCAL1051) GO TO 70                                   MERC      303
                IF (IPLT.EQ.0) GO TO 80                                             MERC      304
                CALL PLOTS (IBUF,1025)                                              MERC      305
305             CALL PLOT (XINT,YINT,-3)                                            MERC      306
                GO TO 80                                                            MERC      307
             70 IF (IPLT.NE.0) CALL PLOT (XINT+XLNG,0.0,-3)                         MERC      308
             80 CALL NEWPEN (IPEN(1))                                               MERC      309
          C     SHIFT ARRAY OF VALUES.                                              MERC      310
310             NUM=NUM-II                                                          MERC      311
                DO 90 K=1,NUM                                                       MERC      312
                VOL(K)=VOL(K+II)                                                    MERC      313
                DIA(K)=DIA(K+II)                                                    MERC      314
             90 CONTINUE                                                            MERC      315
315       C     SCALE X VALUES                                                      MERC      316
                CALL SCALE (DIA,11.,NUM,1)                                          MERC      317
                FIRSTX=DIA(NUM+1)                                                   MERC      318
                DELTAX=DIA(NUM+2)                                                   MERC      319
          C     SCALE Y VALUES                                                      MERC      320
320             CALL SCALE (VOL,8.0,NUM,1)                                          MERC      321
                FIRSTY=VOL(NUM+1)                                                   MERC      322
                DELTAY=VOL(NUM+2)                                                   MERC      323
          C     PLOT DATA, AXES AND HEADINGS                                        MERC      324
                CALL LINE (DIA,VOL,NUM,1,-1,12)                                     MERC      325
325             CALL NEWPEN (IPEN(2))                                               MERC      326
                CALL AXIS (0.,0.,23HPORE DIAMETER (MICRONS),-23,11.,0.,FIRSTX,DELT  MERC      327
               1AX)                                                                 MERC      328
                CALL AXIS (0.,0.,25HPORE VOLUME INTRUDED CC/G,25,8.,90.,FIRSTY,DEL  MERC      329
               1TAY)                                                                MERC      330
330             CALL SYMBOL (1.0,-1.5,0.24,23HPORE VOL. VS. PORE DIA.,0.0,30)       MERC      331
                CALL SYMBOL (999.,999.,.21,W,0.0,10)                                MERC      332
                IBCD=728                                                            MERC      333
                HH=0.2                                                              MERC      334
                ANG=0.0                                                             MERC      335
335             XHH=9.25                                                            MERC      336
                YHH=1.0                                                             MERC      337
                YHH1=YHH+HH/2.0+0.02                                                MERC      338
                CALL SYMBOL (XHH,YHH,HH,IBCD,ANG,0)                                 MERC      339
                IF (PLTYPE.EQ.7LPRNTPLT) GO TO 100                                  MERC      340
340             CALL PLOT (XHH,YHH1,3)                                              MERC      341
                CALL PLOT (XHH+1.0,YHH1,2)                                          MERC      342
                GO TO 110                                                           MERC      343
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      100 CALL PLOT (XHH,YHH,3)                                          MERC  344
          CALL PLOT (XHH+1.,YHH,2)                                       MERC  345
      110 CALL SYMBOL (9.5,1.75,.14,8HPRESSURE,ANG,8)                    MERC  346
          CALL SYMBOL (9.5,1.50,.14,10HINCREASING,ANG,10)                MERC  347
          IF (PLTYPE.EQ.7LPRNTPLT) CALL PLOT (0.,0.,999)                 MERC  348
          IPLT=IPLT+1                                                    MERC  349
      C                                                                  MERC  350
      C     PORE SIZE DISTRIBUTION PLOT                                  MERC  351
      C                                                                  MERC  352
      C     IF THE FINAL PLLT HAS NOT BEEN REQUESTED, BYPASS IT.         MERC  353
      120 IF (IOPT4.EQ.0) GO TO 185                                      MERC  354
      C                                                                  MERC  355
          IF (II.EQ.0) II=1                                              MERC  356
          NUM=STORE                                                      MERC  357
          DO 130 I=1,NUM                                                 MERC  358
          VOL(I)=VOLS(I)                                                 MERC  359
          DIA(I)=DIAS(I)                                                 MERC  360
      130 CONTINUE                                                       MERC  361
          IF (PLTYPE.EQ.7LCAL1051) GO TO 140                             MERC  362
          IF (IPLT.EQ.0) GO TO 150                                       MERC  363
          CALL PLOTS (IBUF,1025)                                         MERC  364
          CALL PLOT (XINT,YINT,-3)                                       MERC  365
          GO TO 150                                                      MERC  366
      140 IF (IPLT.NE.0) CALL PLOT (XINT+XLNG,0.0,-3)                    MERC  367
          CALL NEWPEN (IPEN(2))                                          MERC  368
      150 NUM=NUM-II                                                     MERC  369
      C     FIND DV AND SHIFT DATA TO BEGINNING OF ARRAY                 MERC  370
          DO 160 K=1,NUM                                                 MERC  371
          DV(K)=(VOL(K+II+1)-VOL(K+II-1))/(DIA(K+II-1)-DIA(K+II+1))      MERC  372
          DIA(K)=DIA(K+II)                                               MERC  373
          STORE2=K                                                       MERC  374
          IF (DV(K).LT.0.) GO TO 170                                     MERC  375
      160 CONTINUE                                                       MERC  376
          GO TO 180                                                      MERC  377
      170 NUM=STORE2-1                                                   MERC  378
      C     SCALE Y VALUES                                               MERC  379
      180 CALL SCALE (DV,8.,NUM,1)                                       MERC  380
          FIRSTY=DV(NUM+1)                                               MERC  381
          DELTAY=DV(NUM+2)                                               MERC  382
      C     SCALE X VALUES                                               MERC  383
          CALL SCALE (DIA,11.,NUM,1)                                     MERC  384
          FIRSTX=DIA(NUM+1)                                              MERC  385
          DELTAX=DIA(NUM+2)                                              MERC  386
      C     PLOT DATA, AXES AND HEADINGS                                 MERC  387
          CALL LINE (DIA,DV,NUM,1,-1,4)                                  MERC  388
          CALL NEWPEN (IPEN(2))                                          MERC  389
          CALL AXIS (0.,0.,23HPORE DIAMETER (MICRONS),-23,11.,0.,FIRSTX,DELT MERC  390
         1AX)                                                            MERC  391
          CALL AXIS (0.,0.,25HDVOL./DDIA, (CC/G/MICRON),25,8.,90.,FIRSTY,DEL MERC  392
         1TAY)                                                           MERC  393
          CALL SYMBOL (1.,-1.5,.21,23HPORE SIZE DISTRIBUTION ,0,0,23)    MERC  394
          CALL SYMBOL (999.,999.,.21,W,0,0,10)                           MERC  395
          IF (PLTYPE.EQ.7LPRNTPLT) CALL PLOT (0.,0.,999)                 MERC  396
          IPLT=IPLT+1                                                    MERC  397
      C                                                                  MERC  398
      185 CONTINUE                                                       MERC  399
      C                                                                  MERC  400
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                IF (IOPT2.EQ.0.AND.IOPT3.EQ.0.AND.IOPT4.EQ.0) GO TO 190          MERC    401
400             IF (PLTYPE.EQ.7LPRNTPLT) GO TO 190                               MERC    402
                CALL PLOT (0.,0.,999)                                            MERC    403
                                                                                 MERC    404
              C                                                                  MERC    405
                190 STOP                                                         MERC    406
                200 PRINT 2500                                                   MERC    407
405            2500 FORMAT (1H1,"****** JOB ABORT - INSUFFICIENT INPUT DATA ******")  MERC    408
                END
```

```
      C     CORRECTION FUNCTION                                          MERC     409
      C     VARIABLES USED:                                              MERC     410
      C     A1 - BLANK RUN COUNT  (FROM EQUATION OF LINE)                MERC     411
      C     A2 - COMPRESSION OF SAMPLE    (CC)                           MERC     412
      C     A3 - COMPRESSION OF DISPLACED MERCURY    (CC)                MERC     413
      C     CORR - TOTAL CORRECTION COUNT                                MERC     414
            FUNCTION CORR(INT,SLOPE,MPA,VOLSA,MOD,V,FACT)                MERC     415
            REAL MOD,INT,MPA                                             MERC     416
            A1=INT+SLOPE*MPA                                             MERC     417
            IF (A1.LT.1) A1=0.                                           MERC     418
            A2=3.*(1.-2.*V)*MPA*VOLSA/MOD                                MERC     419
            A3=(4E-5-(1.021E-8*MPA))*MPA*VOLSA                           MERC     420
            CORR=A1+(A2-A3)/FACT                                         MERC     421
            RETURN                                                       MERC     422
            END                                                          MERC     423
```

# APPENDIX B

## MERCURY POROSIMETER; APPARATUS AND TEST PROCEDURE

The mercury intrusion porosimeter provides a means whereby not only the total pore volume, but also the pore size distribution of a sample can be determined. This is accomplished by inundating an evacuated sample with mercury, a non-wetting liquid and then forcing the mercury, under pressure, into the pores and void spaces of the sample. The total volume of mercury which has intruded the sample is measured at each pressure increment by means of a mechanical probe. The pore diameters can be calculated at each pressure using Washburn's equation, if the pores are considered circular in cross-section (2).

A Mercury Penetration Porosimeter manufactured by Micromeritics Corporation of Norcross, Ga. was purchased by MRL for the purpose of testing solid rock samples. Each sample to be tested is first carefully lapped, measured, dried, and weighed. It is then placed in a pyrex sample cell, shown in Fig. 4. The sample cell and sample are weighed together and placed in a pressure vessel inside the porosimeter. They are evacuated, then inundated with mercury. The excess mercury is allowed to drain.

As seen in the figure, there are two tubes rising from the sample space of the sample cell. The contact cup is closed at the bottom but electrically connected to the sample space (now filled with mercury) through a platinum feed-thru. Both tubes are mercury-filled after inundation. A mechanical follower contacts the mercury surface of the precision bore tubing, so that electrical current flows through the follower, bore tubing, platinum feed-thru, and contact cup. An electrical contact immersed in the contact cup completes the circuit.

Air pressure is applied to the sample cell in increments up to atmospheric pressure. Hydraulic fluid is used as the pressure medium from atmospheric to maximum pressure. At each increment, a minute is allowed for stabilization of pressure and temperature. As the pressure increases, forcing the mercury into the rock, the mercury level in the precision bore tubing drops, breaking the electrical current. The mechanical probe follows the mercury down.

Vertical movement of the probe is displayed as integer counts on the control panel of the porosimeter. The increasing count is recorded at each pressure increment.

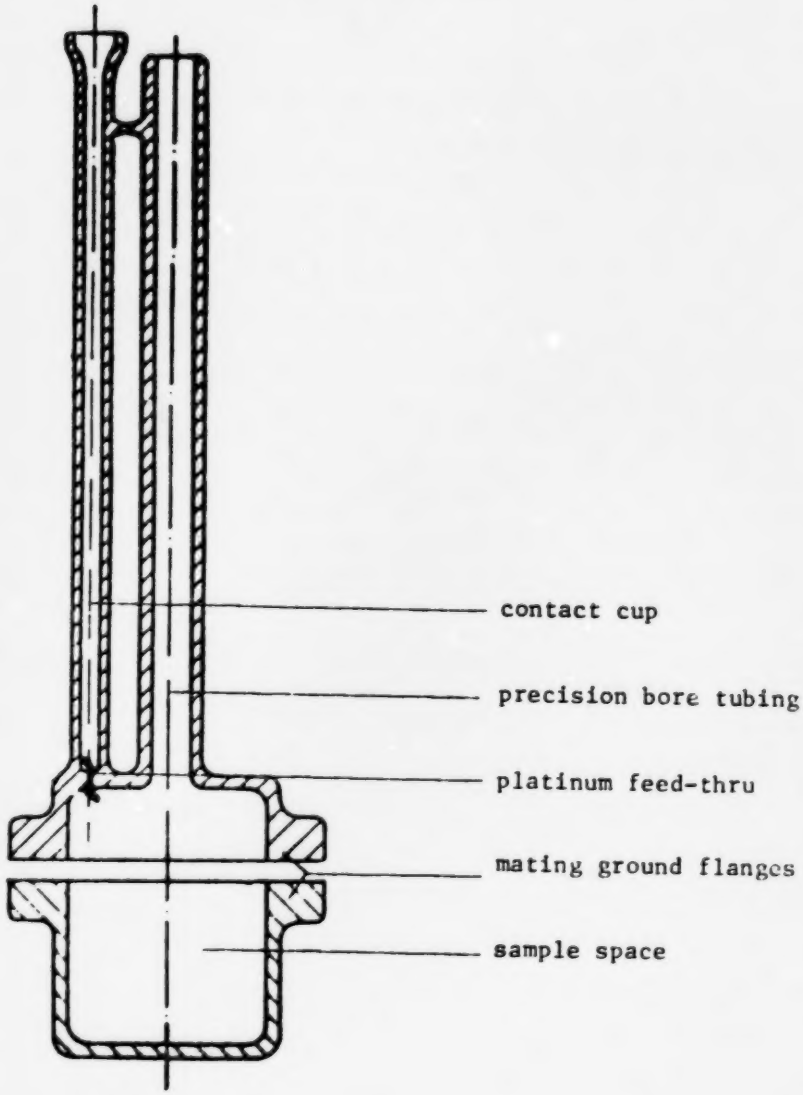


Fig. 4 - Cross-section of pyrex sample cell.

Counts are related to volume change of the mercury in the bore tubing by multiplying by the cell factor (cc/count) for the sample cell, giving apparent intrusion volume.

As the pressure is brought down from maximum pressure, hysteresis counts are similarly recorded. The cell and sample are weighed after the test.

A more complete description of the mercury porosimeter may be found in the MERCURY PENETRATION POROSIMETER MODEL 900 / 910 SERIES INSTRUCTION MANUAL which accompanies the equipment.